

Promoting Energy Efficiency in Cement Making: The ENERGY STAR® for Industry Program

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The ENERGY STAR for Industry Program

As U.S. manufacturers face an increasingly competitive global business environment, they seek opportunities to reduce production costs without negatively affecting product yield or quality. Uncertain energy prices in today's marketplace negatively affect predictable earnings, while increasing energy prices are driving up costs and decreasing their value added. Energy efficiency can be an effective strategy to work towards the so-called "triple bottom line" that focuses on the social, economic, and environmental aspects of a business. In short, energy efficiency investment is a sound business strategy in today's manufacturing environment.

ENERGY STAR is a voluntary government program that offers businesses and consumers a broad range of resources on the best in energy efficiency to help save money and protect the environment. The ENERGY STAR for Industry Program works directly with U.S. manufacturers to help them improve competitiveness through improved energy management, increased energy efficiency, and reduced environmental impact. ENERGY STAR's website provides more information on the program and opportunities to participate (see www.energystar.gov).

To date, the ENERGY STAR for Industry program has established eight different Industrial Focuses in partnership with specific energy-intensive industries in the United States. Current and past Industrial Focuses include motor vehicle manufacturing, corn refining, cement manufacturing, breweries, petroleum refining, glass manufacturing, pharmaceutical manufacturing, and food processing. Many of the companies participating in these Industrial Focuses have reported significant cost and energy savings and have gone on to receive recognition as leaders in energy efficiency and environmental performance. The cement industry was one of the first sectors to actively participate in an ENERGY STAR Industrial Focus, and many of today's U.S. cement companies participate in the program.

As part of each Industrial Focus, participating companies have access to energy professionals who offer assistance to plant energy managers and share proven, non-proprietary approaches for improving corporate energy management. An annual Industrial Focus forum is also held, where companies can openly discuss non-confidential issues confronting their energy management programs.

ENERGY STAR also offers each Industrial Focus two key management tools for improving plant-level energy performance: (1) the plant Energy Performance Indicator (EPI), which is a software tool that allows individual plants to benchmark their energy performance against industry peers using data from the U.S. Census Bureau, and (2) the Energy Guide, which discusses a wide variety of energy efficiency opportunities applicable to plants within the focus industry, including information on best practices for compressed air system efficiency.

The Energy Guides are researched and authored by Lawrence Berkeley National Laboratory (LBNL) in partnership with ENERGY STAR and participating focus companies. The Energy Guides are used by energy managers to identify areas for energy efficiency improvements, to evaluate potential energy improvement options, to develop action plans and checklists for plant-level energy management, and to educate company employees on the importance of and actions for improved energy efficiency.

LBNL developed an Energy Guide for the cement industry as part of the ENERGY STAR Industrial Focus on cement making.¹ This Energy Guide contains an overview of industry trends and energy use as well as detailed information on a large number of energy efficient technologies and energy management practices applicable to a cement plant (see Box 1). This article provides a brief summary of information contained in the Energy Guide.

Box 1: The Energy Guide for Cement Plants

The Energy Guide, which is titled *Energy Efficiency Improvement and Cost Saving Opportunities for the Cement Industry: An ENERGY STAR® Guide for Energy and Plant Managers*, was released by the U.S. EPA in 2004. The Energy Guide is designed to reduce information barriers by providing plant and energy managers with a concise source of state-of-the art information on energy efficiency measures applicable to their plants. The Energy Guide contains detailed information on over 40 energy efficient technologies and energy management practices applicable to the cement plants in the following categories:

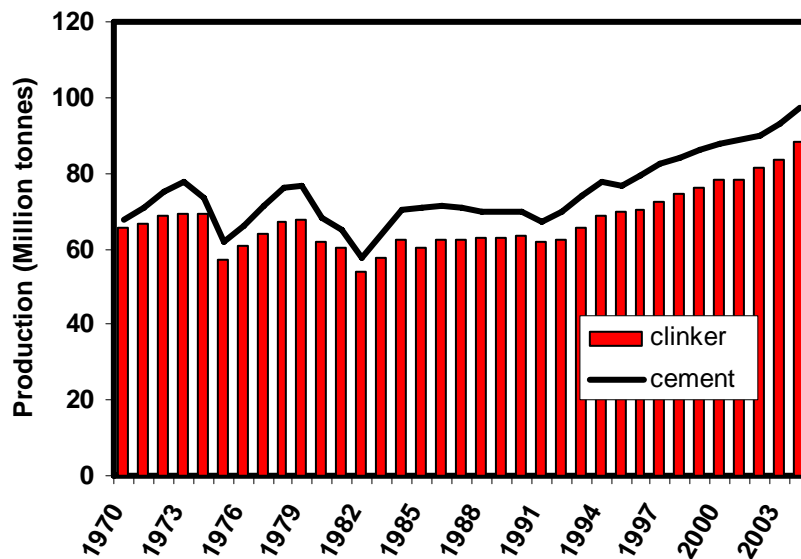
- Energy management programs and systems
- Motor systems
- Compressed air systems
- Kilns
- Grinding (both raw materials and finish grinding)
- Product changes (e.g. blending, limestone addition)
- Emerging technologies

The U.S. Cement Industry

After China and India, the U.S. cement industry is the largest in the world producing 99 Million metric tons (Mt) of cement in 2005. Cement is produced in two steps. First clinker is made by burning a mixture of raw materials (mainly limestone). The clinker is then ground and mixed with other materials (e.g. gypsum, limestone or additives such as fly ash or blast furnace slag) to make cement. The industry is made up of integrated plants that produce clinker and grind it to make finished cement, and cement plants that grind purchased clinker and additives. In the U.S., there are currently no stand-alone clinker plants. There were 115 operating cement plants in the U.S. in 1999, spread across 37 states and Puerto Rico. The top-10 leading companies produced over 80% of the cement in the U.S. Cement companies in the U.S. produced \$8 Billion of cement, while the cement market in the U.S. represents a value of \$10 Billion. The majority of U.S. cement capacity is owned by multinational companies. Production rates per plant vary between 0.5 and 3.1 Mt per year.

Clinker and cement production experienced gradual growth since the 1970s, with prominent dips in the late 1970s and early 1980s (see Fig. 1). Within this slow production increase, the composition of clinker production changed significantly since 1970. Clinker produced with the energy-intensive wet process decreased from a 60% share of total clinker production in 1970 to a 16% share in 2004. Clinker produced with the dry process increased from a 40% share of total clinker production in 1970 to a 78% share in 2004, with the remaining 6% not classified as wet or dry process. Cement production increased from 69 Mt in 1970 to 99 Mt in 2005. Cement production grew more rapidly (1% average per year) than clinker production (0.8% average per year) between 1970 and 2004, due to increased use of additives and increased clinker imports.

Figure 1. Clinker and Cement Production in the United States from 1970 until 2004.²



Energy Use

The cement industry is one of the most energy intensive industries, with energy representing 30-40% of production costs. In 2004, the U.S. cement industry consumed 531 TBtu of primary energy.

Energy consumption in the U.S. cement industry declined between 1970 and 1999. Primary energy use decreased at an average of 0.3% per year, from 556 TBtu in 1970 to 531 TBtu in 2004, although production increased over that time span. Since the 1980s the use of waste derived fuels is growing in the cement industry.. By 2004 over 12% of all fuels were waste derived fuels, e.g. tires, solid and liquid wastes (solvents), which is low compared to some European countries. The trend towards increased use of waste derived fuels will likely increase.

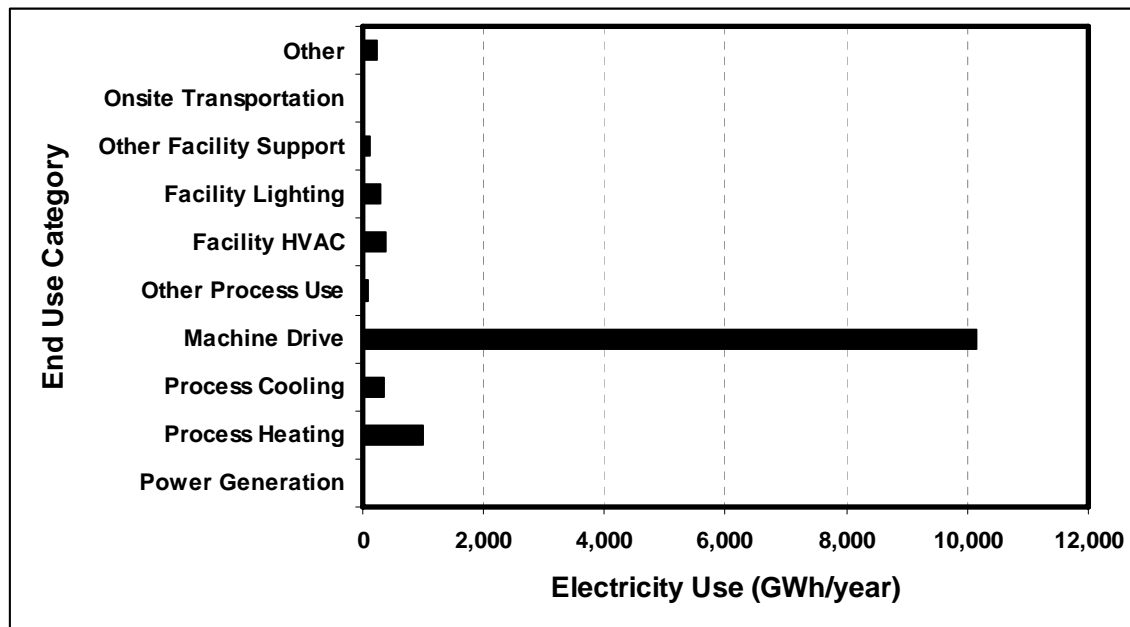
While fuel is the main energy input in the cement making process, electricity use is still considerable. In 2004, the cement industry consumed nearly 14 TWh of electricity (or

11% of total energy inputs, on a final energy basis). Electricity use is a considerable cost exceeding \$617 Million per year. On average the U.S. cement industry consumes 142 kWh/metric ton of cement.

The major end uses of electricity in the industry are summarized in Figure 2.³ Electricity is mainly used for drives, of which the motors used in grinding processes and kiln drives are the key energy uses. Combined all drives consume about 80% of all electricity. Of the drive systems, compressed air is a relatively small end use, estimated at about 6% of the industry's electricity use, or nearly 850 GWh (equivalent to an estimated cost of over \$40 Million/year, or enough to power 80,000 U.S. households).

Compressed air is used in many parts of the plant for many uses including silo control, on-site transport of raw materials to the kiln, baghouse collector filters, air knives, dedusting and, especially, in wet process clinker plants in the mixing of raw materials to prepare a slurry that is fed to the kiln.

Figure 2. Estimated Breakdown of Electricity Use in the U.S. Cement Industry, 2002



Best Practices for Compressed Air Systems

Despite the small share in electricity use, compressed air is an area where low-cost but relatively large savings can be found, as evidenced by some of the ENERGY STAR partners. Compressed air is by far the most costly energy carrier in almost any facility. Many opportunities to reduce energy consumption in compressed air systems are not prohibitively expensive; in fact, payback periods for some options (such as improved system maintenance) can be extremely short. Energy savings from compressed air system efficiency improvements can typically range from 20% to 50% of total system electricity consumption.⁴ The Energy Guide for cement plants provides detailed information on a number of proven, cost-effective measures for improving the energy

efficiency of compressed air systems. A summary of the efficiency measures discussed in the Energy Guide is provided in Table 2.

Information on best practices for compressed air system energy efficiency was compiled by LBNL from a wide variety of sources from various programs (e.g. U.S. Department of Energy, U.S. Environmental Protection Agency), industry, and national and international sources.

Often, plant and energy managers do not have the time, budget, or resources to obtain such detailed information on efficient technologies or improved efficiency practices. This lack of information can be a major barrier to industrial energy efficiency improvement at many U.S. plants. The aim of the Energy Guide is to reduce this information barrier by providing plant and energy managers with a concise source of state-of-the art information on energy efficiency measures applicable to their plants, while also arming them with enough basic information to understand the potential energy and cost savings associated with each measure.

In the discussion of each energy efficiency measure, the Energy Guide typically provides:

- A brief description of the efficiency measure, including any limitations on applicability
- An estimate of typical energy savings associated with the measure
- An estimate of typical cost savings associated with the measure, including the simple payback period associated with any investments
- An industrial case study to illustrate successful application of the measure, when available
- References to publicly-available sources of additional information

Plant and energy managers are encouraged to consult the references and tools recommended in the Energy Guide to facilitate a more in-depth assessment of the applicability of any given energy efficiency measure to their specific plant.

Table 2. Summary of Compressed Air System Energy Efficiency Measures Included in the Energy Guide for Cement Plants

System upgrades and improvements	Improved load management
Improved maintenance	Pressure drop minimization
System monitoring	Inlet air temperature reduction
Leak reduction	System controls
Turning off unnecessary compressed air	Properly sized pipe diameters
Modification of system in lieu of increased pressure	Heat recovery
Replacement of compressed air by other sources	

Box 2: Compressed air system efficiency at California Portland Cement Company

California Portland Cement Company (CPCC) operates three clinker and cement plants in Arizona and California. The company is an ENERGY STAR partner and was awarded the 2005 and 2006 Partner of the Year award, while two of its plants received the 2006 ENERGY STAR award for their overall energy performance. CPCC launched a strategic corporate-wide energy management system. CPCC realized that large energy savings can be achieved by assessing the compressed air systems. CPCC cut its electricity use by 10% (or 31 GWh/year) as part of the efforts undertaken as part of the ENERGY STAR program. The baghouse pulse jet or plenum pulse dust collectors are a major consumer of compressed air in virtually all cement plants, whereas compressed air is also used at other miscellaneous areas in the plants. In the assessments CPCC identified the following opportunities for reducing energy use for compressed air:

- *Shut down of the compressed air system and dust collector system when the mills are not in use*
- *Leak reduction, which at one plant alone saved over \$30,000 year for a single leak*
- *Shut-off of auxiliaries running idle (for which the total power use was estimated at 0.5 MWe at a single plant)*
- *Reduction of air pressure from 85 psi to 65 psi*
- *Reduction of inappropriate use of compressed air (e.g. dedusting of the work floor)*
- *Use of NEMA Premium efficiency motors, whenever a motor is replaced*
- *Replacement of V-belts by cog belts*
- *Improved maintenance.*

Combined the measures saved \$100,000 per year for all three plants operated by California Portland Cement Company, and were realized at low payback periods.

Additional Information

For additional information on the ENERGY STAR for Industry Program, please visit: <http://www.energystar.gov/industry>. For information Energy Guide for Cement Making, please contact: Ernst Worrell, Lawrence Berkeley National Laboratory, Email: eworrellt@lbl.gov.

End Notes

¹ *Energy Efficiency Improvement and Cost Saving Opportunities for the Cement Industry: An ENERGY STAR® Guide for Energy and Plant Managers.* By Ernst Worrell and Christina Galitsky. Lawrence Berkeley National Laboratory, Berkeley, California. LBNL-54306. 2004. The report can be found at: http://www.energystar.gov/index.cfm?c=in_focus.bus_cement_manuf_focus

² Based on data provided by the United States Geological Survey's Mineral yearbooks (multiple years).

³ Estimated using energy consumption data from the U.S. DOE *Manufacturing Consumption of Energy*, 2002 and 1994 data tables, and electricity end use breakdown data for motors from U.S. DOE (1998), *United States Industrial Motor Systems Market Opportunities Assessment*, Office of Industrial Technologies, Washington, D.C.

⁴ Efficiency Partnership (2004). *Industrial Product Guide – Manufacturing and Processing Equipment: Motors*. Flex Your Power, San Francisco, California.